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NRP 49: Antibiotic resistance

Final Summary

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Prediction and Predictability of Resistance to Antibiotics: Studies based on Coupled Map Lattices

Prediction and predictability of resistance: spatial studies

One among many lines of attack which can be taken to combat bacterial resistance to antibiotics consists of adjustment of population sizes and control of movement among populations (quarantine, for example) along with adjustment of antibiotic usage, which may be different in different populations.

Research questions

We ask two basic questions. (1) When is the spread of antibiotic resistance unpredictable? Unpredictability would have serious consequences for the logical basis of combating resistance. (2) What sort of populations measures and antibiotic usage in the different populations can diminish the problem of resistance while at the same time minimizing illness due to nonresistant bacteria and using as little antibiotic as possible? An example of what we mean by populations would be the various communities in a metropolitan area.

Results

(1) A system can be unpredictable if it develops in time chaotically or if it possesses a large inherent variability. For a simple model of the spread of infection in coupled populations which in principle can yield chaotic unpredictability, predictability is maintained as long as one is satisfied with average levels of infection. For an important case in which the degree of inherent variability in infections is large, so called scale-free networks, we developed a mathematical “trick” which allows one to recover predictability. In these simple cases resistance is either predictable or may be made so.
(2) Assuming that minimal use of antibiotics is desirable in the fight against resistance we studied a central population surrounded by peripheral populations. The eradication of an infection at minimal total antibiotic level occurs when (a) antibiotic is used only in the smaller of the central and the total peripheral populations; (b) the infection is not allowed to spread from the smaller to the larger population but is encouraged to move in the other direction; (c) the spread among the peripheral populations may have to be limited. These theoretical results should be considered cautiously before they are be deemed appropriate for use in the real world. Even then, they could well be controversial and difficult to implement in a political and social context.

Perspectives

In the best of all worlds one wants to simultaneously minimize total antibiotic use (not instantaneous use, as above) and the level of infection over time, to inhibit resistance and reduce disease and death caused by the infection. These two goals are contradictory, however, since less antibiotic implies more infection and vice versa. The way around this dilemma is given by optimal control. We hope to expand our work in this direction.